

Product Differentiation and Firm Size Distribution: An Application to Carbonated Soft Drinks

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Abstract

Using brand level retail data, the firm size distribution in Carbonated Soft Drinks is shown to be an outcome of the degree to which firms have placed brands effectively (store coverage) across vertical (flavour, packaging, diet attributes) segments of the market. Regularity in the firm size distribution is not disturbed by the nature of short-run brand competition (turbulence in brand market shares) within segments. Remarkably, product differentiation resulting from firms acquiring various portfolios of product attributes and stores in market evolution determines the limiting firm size distribution.

Key words: Firm Size Distribution; Product Differentiation; Carbonated Soft Drinks.

JEL Classification: L11, L66, D40

Introduction

Economists have long been consumed by the desire to identify and understand the mechanisms driving firm size distributions. The literature before Sutton (1998) left us with a legacy that failed to generalise on a form of firm size distribution.ⁱ Sutton (1998) provides us with a new empirical approach.ⁱⁱ Rather than looking for an exact size distribution, he derives a lower bound to firm size distribution that will hold in any industry where firms operate over segments that have emerged in the history of the marketⁱⁱⁱ. The lower bound is a limiting outcome driven by a sequence of deterministic entry games across the segments of the market. Theoretically, differences in firm coverage of segments override the details of events within segments in determining the limiting size distribution.

To date the empirical validation of this theory defines segments in terms of geographic location in the US Cement Industry (Sutton, 1998), the Spanish Retail Banking Sector (De Juan, 1999) and the Italian Motor Insurance Industry (Buzzacchi and Valletti, 1999). These industries host a homogenous product line. The lower bound to firm size distribution at the national level is not violated in any of these studies. In the case of the US Cement Industry, we observe firms of similar size within each State. The inequality at the national level is mainly determined by the varying presence of firms across geographical locations^{iv}. To be a large firm at the national level requires a presence over many States. This point was also shown for

Retail Banking and Motor Insurance. As predicted by Sutton's (1998) theory, the degree of coverage (portfolios) of geographical locations by firms can by itself explain most of the observed differences in firm size at the national level.

Using the Sutton (1998) framework we model the firm size distribution in Carbonated Soft Drinks in the Irish retail market using AC Nielsen data on the population of 178 brands belonging to 13 firms operating over 40 product characteristics and 27 bi-monthly periods, 1992-1997. The retail market for Carbonated Soft Drinks in Ireland is broadly similar to the U.S. There are differences between Ireland and the US that are typical of European Carbonated Soft Drinks markets [see Sutton (1991)]. These differences are highlighted in our data section. Companies in the business of Carbonated Soft Drinks produce products defined by various flavour, packaging and diet attributes. To allow for flavour segments (Cola, Orange, Lemonade and Mixed Fruit) is standard in the analysis of Carbonated Soft Drinks [see Sutton (1991) and Dubé (2000)]. Moreover, Dubé (2000), using household data to estimate the short-run impact of soft drink mergers, highlights the need to define product attributes further by nutritional content and packaging size.

Sutton (1998) predicts that market segmentation and heterogeneous operations over such segments by firms imposes a limiting lower bound to firm size distribution, or a minimum degree of inequality that will generate a Gini co-efficient of at least 0.5. We are the first to

provide an empirical validation of the Sutton (1998) bounds approach using counts (portfolios) of vertical segments as a key determinant of firm size, where forty market segments are defined by different combinations of flavour, packaging and diet attributes^v. Measuring firm size based solely on portfolios of product attributes, for example a firm has a size of ten if it has at least one brand in ten segments, generates a firm size distribution above the mathematically predicted lower bound. The Lorenz-curve analysis for every bi-monthly period is supplemented with an econometric model of firm size. The results show us that company coverage of market segments, amongst other factors, has great explanatory power and induces significant regularity in the firm size distribution over the period 1992-1997.

A count on product attributes assumes that all firm sales are the same within and across the segments of the market. Differences in the intensity of short-run price competition within segments will not lead to violations of the lower bound, but is shown theoretically to push the size distribution further inside the bound. Our data allows us to test this proposition. We extend the Lorenz-curve analysis and the econometric model of firm size by weighting a presence in a vertical (product) attribute by horizontal (store) coverage within a segment. For example, if shop coverage by a firm within a segment is only fifty per cent of the store population, rather than attributing one to firm size due to having a presence in a defined segment we attribute 0.5. One can also weight store coverage in terms of the size of the store in Carbonated Soft Drinks turnover. This gives us an

analysis of *effective* firm coverage of market segments. In other words, we allow for different portfolios of stores (generating varying degrees of horizontal product differentiation) within segments. Firm size measured on the basis of *effective* coverage of product segments not only pushes the size distribution further inside Sutton's (1998) mathematically predicted lower bound, but also explains most of the actual firm size distribution. In the history of the market firms accumulate various portfolios of product attributes and stores, as an outcome of many strategic entry games. Remarkably, the structure of how firms operate over such vertical and horizontal dimensions of the Carbonated Soft Drinks market determines the limiting firm size distribution.

Finally, to understand how brand market share turbulence within segments will not lead to violations of the lower bound or indeed disturb the regularity in the firm size distribution in Carbonated Soft Drinks we test a final assertion of Sutton's theoretical framework. Theory shows that competition can generate within segment size distributions of various forms. If segmentation exists and firms have heterogeneous operations over these segments, then any changes in firm sales within segments will only have second order effects on the aggregate inequality and will not lead to violations of the lower bound. We show that short-run brand market share rivalry is localised within our product segments, and within segment competition is augmented by the nature of store coverage by brands. The nature of product differentiation on two dimensions is shown to dictate and constrain the nature of competition between brands. Size

distributions of firm sales within product segments take on many forms and vary over-time. Yet, the details of within segment sales activity do not override the effect that heterogeneous coverage of segments by firms has on the firm size distribution at the level of Carbonated Soft Drinks.

Remarkably, product differentiation resulting from firms acquiring various portfolios of stores and product attributes in market evolution determines the limiting firm size distribution. So while the Coca-Cola Company has on average 52 per cent of the Carbonated Soft Drinks retail market in Ireland over the period 1992 to 1997, its dominance does not result from its performance in the Cola market. Rather, its success lies in the establishment of a portfolio of brands across 91 per cent of the vertical segments with an effective (weighted by store coverage within segments) coverage of 58 per cent. Smaller firms operate alongside the multinationals by specialising into various vertical and horizontal segments of the market. The nature of product differentiation is shown to have important implications for anti-trust work.

I. Data Description

AC Nielsen, an international marketing research company, has collated a panel database of all brands in Carbonated Soft Drinks distributed throughout Irish retail stores for use in our empirical analysis. The evolution of the Irish retail grocery market structure from the early 1970s is described in Walsh and Whelan (1999a).

Unlike the UK retail market for Carbonated Drinks “own brands” are not a feature of the Irish Market. The retail market for Carbonated Soft Drinks in Ireland is broadly similar to the U.S. We have a similar style of chain stores and corner shops and a heavily branded market. In 1997, the top two firms collectively account for 73 per cent of the Irish market and 75 per cent of the US retail market. Inequality in retail sales as measured by the Gini co-efficient is 0.72 in Ireland and 0.68 in the US. There are differences between Ireland and the US that are typical of European Carbonated Soft Drinks markets. These differences are highlighted in case studies of several countries in Sutton (1991). The Cola segment of the market is 35 to 40 per cent in Europe, compared to 63 per cent in the US. While Pepsi has a smaller share of the Cola segment in Europe, it is merged with 7-UP outside the US. The nature of bottling is not fully integrated in Europe allowing smaller firms to co-exist with the multinationals. Finally, while flavour segments are similar to the US in Ireland, Root Beer and Dr. Pepper type brands never took off.

The database provides bi-monthly population data spanning October 1992 to March 1997 for 178 brands, identified for 13 firms and 40 product characteristics within the particular “business” of Carbonated Soft Drinks^{vi}. The data record the retail activities of both Irish and foreign owned brands/firms selling throughout the stores of the Irish retail sector^{vii}. We are bound by a contract of confidentiality with AC Nielsen not to reveal information not otherwise available on the market. We have extensive bi-monthly brand level information regarding information on brand price

(average of individual brand prices across all stores selling the brand weighted by brand sales share within the store), quantity (in ml), sales value (in £000), distribution structure (number and size of the stores through which the brand retails), firm attachment and their vertical (flavour, packaging, and diet) characteristics. An interesting feature of the AC Nielsen data is their identification of various segments within the market for Carbonated Soft Drinks, which group clusters of brands by 40 characteristics: 4 flavours (Cola, Orange, Lemonade and Mixed Fruit), 5 different packaging types (Cans, Standard Bottle, 1.5 Litre, 2 Litre and Multi-Pack of Cans) and 2 different sweeteners, diet and regular. Packaging format is recognised as a crucial feature of this market. Over 90 per cent of cans and standard bottles are impulse buys distributed through small corner stores and garage forecourts rather than chain stores. In contrast, the majority of 2 litre and multi-pack cans are distributed through one-stop supermarket shopping. The industry has clearly introduced different packaging to satisfy different consumer needs within both the impulse and one-stop shopping segments (Walsh and Whelan, 1999a).

We define the firm business as Carbonated Soft Drinks, but within this market firms place brands, or take-up roles, across various segments of the market. So if a firm operates in all segments, it has adopted 40 different roles. Details of the segments and associated number of firm roles and brands they host are set out in Table 1. Interestingly there are only 100 roles taken up, on average, by the 13 firms. If every firm operated in every segment we would have 13

firms in each of the 40 segments giving a total of 520 roles. There is a very heterogeneous and a persistent pattern in the take up of roles by firms across vertical segments. This will be shown to be a key structural feature of the industry, particularly when weighted by the coverage of stores within segments, in the determination of the limiting firm size distribution.

II. Theoretical Framework

A market is made up of segments that host at least one investment opportunity. The key structural feature of Sutton's (1998) theory is the arrival of a number of discrete investment opportunities over an infinite period in the history of the market. Assuming opportunities of equal size arrive and are taken up by a firm, the market begins with a single firm of size 1. Each subsequent opportunity is taken up by either a new firm or existing firm. If opportunities were taken up in succession by new firms, the resultant limiting size distribution will display perfect equality between firms of size 1. Differences in firm sizes emerge when firms have taken up a different number of opportunities across the segments of the market. Sutton (1998) puts weak restrictions on the form of the entry game into segments that host investment opportunities to model a lower bound on the size distribution of firms in a market. A symmetric equilibrium in mixed strategies can be calculated where each firm has an equal probability of entering a segment to take up an opportunity and therefore have 'equal treatment'. By imposing a symmetry requirement on the strategy space of each subgame, all equilibria are excluded except

this mixed strategy equilibrium. Sutton (1998) derives his lower bound within a game-theoretic model using this *Symmetry Principle* when modelling deterministic entry processes across the segments of the market.^{viii}

Firm size in this case is simply equal to the total number of segments over which they operate. Firm size distribution, based on a simple count of segments, is restricted to a lower bound Lorenz curve. The limiting Lorenz curve graphs the fraction of top k ranking firms in the population N of firms, k/N , against their corresponding market share, given by the k -firm concentration ratio, C_k , that satisfies,

$$C_k \geq \frac{k}{N} \left(1 - \ln \frac{k}{N} \right) \quad (1)$$

Segmentation and heterogeneous participation of firms across segments dictates a lower bound to firm size distribution in a market that is associated with a Gini co-efficient of 0.5. This is the *first prediction* that we will test in the next section. One can augment the framework to allow firm size advantages (scope economies) in the take up of opportunities, or violations of the *Symmetry Principle*. This induces more heterogeneity in firm size during market evolution and a resultant size distribution that is inside the limiting lower bound.

The size of a firm within segments can differ due to differences across segments in the nature of short run price competition. The affect of introducing this additional dimension in measuring firm

size is to introduce additional heterogeneity between firms in the market and so greater skewness. Thus, firm size distribution that allows for roles of different sizes will result in a Lorenz curve that lies above that based on a pure count of roles across segments. This is the basic proposition in the theorem of majorisation (Marshall and Olkin, 1979). We will test this *second prediction* by allowing firm size within segments to depend on store coverage. Heterogeneity in shop coverage by firms within segments is predicted to push the size distribution further inside the bound^{ix}.

Finally, the size of roles, or firm size within segments, depends on the intensity of competition between brands of firms. Hence, in the absence of very special conditions, not applicable to Carbonated Soft Drinks, there are no theoretical restrictions on the shape of role size distribution within segments.^x The distribution of firms within segments can therefore be either very skewed or very equal. We test a *third prediction*, that irrespective of the nature of size distributions within segments, the heterogeneous coverage of segments by firms is predicted to generate a firm size distribution that will not violate the lower Bound.

III Lorenz Curve Analysis Carbonated Soft Drinks

The actual firm size distribution observed in the Carbonated Soft Drinks market is illustrated in Figure 1, averaged over the five-year period and for each bi-monthly period. This measures firm size as total firm sales in the business of Carbonated Soft Drinks, and plots

the fraction of top k ranking firms in Carbonated Soft Drinks, k/N , against their corresponding market share in Carbonated Soft Drinks. N is the total number of firms and C_k describes the k -firm sales concentration ratio in the market. For example, the top 25 per cent of firms collectively account for, on average, over 80 per cent of the market. We do not observe a violation of the predicted lower bound in our scatter of points in any bi-monthly period. The corresponding Gini co-efficient measure of inequality is 0.72, which clearly exceeds the mathematically predicted lower bound or a Gini co-efficient of 0.5.

We first test the prediction that segmentation and heterogeneous participation of firms across segments dictates a lower bound to firm size distribution in a market. We analyse whether the presence of firms operating over vertical segments in Carbonated Soft Drinks places this lower bound on the shape of the firm size distribution. Each firm is given one mark for each segment it is active in. The size of the firm in the Carbonated Soft Drinks market is simply equal to the number of segments across which a firm operates. The percentage of segments (flavour, packaging, diet attributes) covered by firms ranges from 2 to 91 per cent, with a tendency for higher ranked firms to cover relatively more segments. Figure 2 illustrates the size distribution of firms on the basis of a count of segments (flavour, packaging, diet attributes), within Carbonated Soft Drinks on average over the five-year period, and for each bi-monthly period. The fit of the data to the theoretically predicted lower bound Lorenz Curve is remarkably tight for each and every period. Firm

size inequality that is only driven by the heterogeneous operations of firms across vertical segments corresponds to a Gini co-efficient of 0.56, and lies above the mathematically derived lower bound predicted in Sutton (1998).

Secondly we test the prediction that when one allows for roles of different sizes, this will result in a Lorenz curve that lies above that based on a pure count of roles. A presence in each vertical segment is weighted by the percentage of stores retailing the firm's brands within the segment. The size of the firm is no longer a simple count of segments that a firm has a brand in, but rather a count over fractions of these segments. Figure 3 augments the Lorenz curve analysis to allow for the fact that having a partial coverage of shops within a segment can reduce the effective presence of a firm in a vertical segment. Thus, the effective operation of firms over vertical segments induces further heterogeneity in firm size and a Lorenz curve that is bowed further out from one based on a simple count of roles over vertical segments alone. This is evident in the Lorenz curve of Figure 3, which corresponds to a Gini co-efficient of 0.69, on average.

The above Lorenz curve analysis is based on measures of effective coverage that uses a pure count of stores. One can weight store coverage in terms of the size of the store in Carbonated Soft Drinks turnover. The count of stores covered weighted by the share of each store in Carbonated Drink sales reflects the fact that a firm may target distribution in bigger or smaller stores. Effective

coverage of market segments ranges from 1 to 58 per cent. Figure 4 is the Lorenz curve outcome when each role is weighted by the degree to which firms effectively cover retail stores in the Carbonated Drinks Market, that is, the percentage of Carbonated Drink sales accounted for by the stores in which a firm is located or retails. Inequality in firm size that is driven by the heterogeneous effective operation of firms over vertical segments when coverage of stores reflect store size within segments corresponds to a Gini co-efficient of 0.70, on average. Changing the weighting to reflect effective coverage within segments leads to slightly more inequality. In both cases allowing for roles of different sizes results in a Lorenz curve that lies above that based on a pure count of roles.

Inequality between firms based only on a count of roles over segments weighted by effective coverage of stores within segments provides evidence for Sutton's (1998) theory. Allowing for firms to have different portfolios of stores within segments not only pushes the inequality in firm size distribution further inside the bound but the actual size distribution in Figure 1, with a corresponding Gini co-efficient of 0.72, is just slightly above the size distribution based on a weighted (by effective store coverage within segments) count of roles across 40 vertical segments observed in Figure 4. Remarkably, product differentiation resulting from firms acquiring various portfolios of product attributes and stores in market evolution seems to determine most of the actual firm size distribution. We supplement this Lorenz curve analysis with an

econometric model of firm size and an econometric model of market share rivalry within segments over the next two sections of the paper.

IV An Econometric Model of Firm Size

We wish to evaluate the statistical significance of firm coverage of product segments and stores within these segments as a determinant of firm size in the business of Carbonated Soft Drinks. We construct our dependent and independent variables from information on 178 brands produced by 13 firms over 27 bi-monthly periods. The dependent variable corresponds to the observed size level for firm f at a given point in time, t . We sum over the unit sales of the brands belonging to the firm to get firm size measured in unit sales of Carbonated Soft Drinks. Firm size depends on a number observable and unobservable factors. The basic model may be written as follows,

$$\ln \text{SIZE}_{ft} = \alpha + \beta_1 \ln \text{COVERAGE}_{ft_0} + \beta_2 \ln \text{CYCLE}_{ft} + u_f + \varepsilon_{ft} \quad (2)$$

The variable *COVERAGE* controls for the percentage of vertical segments that the firm has at least one brand in. We base our regressions on coverage over 40 segments. Persistent participation rates and a potential endogeneity problem induce us to use coverage in the initial period of the data. In addition, we use two measures of effective coverage where the presence in a vertical segment is weighted by either the percentage of stores retailing the firm's brands within the segment, or the percentage of stores (weighted by

size) retailing the firm's brands within the segment in the initial periods. We also control for changes in the business cycle or seasonal effects with the variable *CYCLE*. This represents total product unit sales in the current period (excluding the firm's sales), with higher values indicating boom periods. As an alternative, we also use a more refined measure of the business cycle with unit sales only of the vertical segments that a firm is in (excluding the firm's sales), since the cyclicalities of consumer demand can be very different for different vertical attributes.

Unobserved heterogeneity between firms is controlled for by the inclusion of a unit specific residual, u_f , which comprises of a collection of factors not in the regression that are firm specific and constant over time. For example, we have no data on advertising expenditures or costs of production. Failure to acknowledge unobserved heterogeneity among cross-sectional units would inevitably result in biased estimates of the model. The factors that affect the value of the dependent variable but have not been explicitly included as independent variables are appropriately summarised by a random effect across cross-sectional units that is assumed to be independent of the other regressors. The use of a random effect model was justified on the basis of a Hausman (1978) test of independence of u_f with the other regressors. We also use a Hausman specification test to see whether our model of firm size based on the presence of 40 segments generates more efficiency and explanatory power than that created by repeating the same analysis either by 4 flavours or by 20 flavour by packaging segments.

In Table 2 (a), (b) and (c) we present our econometric results. In Table 2 (a) we measure coverage as the percentage of the 40 vertical segments that the firm has at least one brand in, in the initial period of the data. As the sole explanatory variable in Column I it explains 52 per cent of our observations on firm size using a simple OLS estimator. We build up the model with a measure of the business cycle based on unit sales of all Carbonated Soft Drinks and firm random effects, accepted on the basis of the Hausman Specification test. GLS estimates are presented in column III. The presence of an auto-correlated error structure of order one in the GLS models led us to adopt a transformation of the data to obtain the unbiased estimates of the coefficients presented for the AR(1) in column IV. The cross-section variation in firm size is explained reasonably well by firm coverage of vertical segments, although the time series variation is not well explained using the business cycle of the market. In the last three columns we repeat the exercise using a measure of the business cycle for firms with unit sales only of the vertical segments that a firm is in. The overall, in addition to within and between, explanatory power improves to 0.66 per cent. Finally based on the regression in column VI we report Hausman specification tests to see whether we get efficiency gains from having 40 segments when compared to having 4 flavour or 20 flavour by packaging segments. The reported Hausman test, in both cases, accepts the null hypothesis that the difference in co-efficients between the two specifications is systematic. We have a better model

of firm size allowing for heterogeneous operations over 40 segments rather than just 4 or 20 segments.

In Table 2 (b) we undertake exactly the same exercise as Table 2 (a), except we refine our measure of coverage of vertical segments in the initial period of the data to an effective measure that weights firm presence in a segment by the percentage of stores retailing the firm's brands within the segment. As the sole explanatory variable in column I it explains 73 per cent of our observations on firm size using a simple OLS estimator. In the last three columns using a measure of the business cycle for firms with unit sales only of the vertical segments that a firm is in, the overall explanatory power is 0.78.

In Table 2 (c) we undertake exactly the same exercise, refining our measure of coverage further by weighting vertical coverage by the size weighted percentage of stores retailing the firm's brands. As the sole explanatory variable in column I it explains 75 per cent of our observations on firm size. In the last three columns using a measure of the business cycle for firms with unit sales of the vertical segments that a firm is in, the overall explanatory power increases to 0.81.

In summary, a very simple model of firm size based on measures of effective coverage of vertical segments and segment business cycles as observable factors, controlling for unobservable firm effects, has remarkable explanatory power. As suggested by our

Lorenz curve analysis the size of a firm based on its portfolios of product attributes and stores in market evolution determines most of the actual firm size distribution^{xi}. In the next section we understand how brand market share turbulence within segments do not lead to violations of the lower bound or indeed disturb the regularity in the firm size distribution in Carbonated Soft Drinks. This tests the final assertion of Sutton's theoretical framework.

V Within Segment Analysis of Carbonated Soft Drinks

We wish to show that short-run brand market share rivalry is localised within our product segments, and within segment competition is augmented by the nature of store coverage by brands. In other words, that product differentiation on two dimensions determines the nature of competition between the 178 brands in Carbonated Soft Drinks. We validate the presence of segmentation by product characteristics applying Hausman, Leonard and Zona (1994) and Hausman (1996). They use the idea of multi-stage budgeting to construct a multi-level demand system for differentiated products to evaluate the short-run impact of new brands^{xii}. Our objective is to validate the presence of product segments and show that market share turbulence within these segments has second order effects on the overall size distribution. We wish to test whether we have weak separability of consumer preferences across the a priori segmentation of the market by our product attributes. As outlined in Hausman, Leonard and Zona (1994), weak separability of preferences is necessary and sufficient if

in the last stage of multi-stage budgeting brand expenditure within segments depends more on *segment* real income (rather than aggregate business cycles) and the price of the other brands within the segment (rather than from brands hosted in other segments), amongst other factors. To calculate overall price elasticities using multi-stage budgeting requires much more structure and stricter forms of independence.

The precise form of the brand level expenditure function to be estimated in logs is written as the following,

$$\ln E_{ist} = \alpha_0 + \alpha_1 \ln S_{st} + \alpha_2 \ln C_{ist} + \alpha_3 \ln P_{ist} + \alpha_4 \ln \sum C_{jst} P_{jst} + \alpha_5 M_t + \alpha_6 F_f + \alpha_7 S_s + U_i + \varepsilon_{it} \quad (3)$$

The dependent variable measures brand *i* expenditure share within one of the 40 segments *s* of Carbonated Soft Drinks over a bi-monthly period. S_{st} is real segment income, measured by the total sales units of all brands in the segment. C_{ist} is a store coverage variable for brand *i*, it measures the percentage of stores (weighted by store size) that a brand covers. P_{ist} is the price of the brand, in Irish pounds, deflated using a paasche price index. The impact of other brand *j* prices in the segment is weighted by each brands horizontal distance from the market in terms of shop coverage, C_{jst} . The weighted average of other brands deflated prices in the Carbonates market is thus $\sum C_{jst} P_{jst}$. A direct impact of store coverage, C_{ist} , on brand market shares and its indirect effect through

cross-price effects will indicate to us that horizontal product differentiation matters for market share rivalry. This is an outcome of brands hosting varying shop portfolios. We control for macro factors with month dummies, M_t , Firm dummies, F_f , and segment dummies, S_s , which controls for the possible influence of time, firm and segment effects. Unobserved heterogeneity between brands is controlled for by the inclusion of a unit specific residual, U_i , which comprises of a collection of factors not in the regression that are brand specific and constant over time. For example, we have no data on costs of production. Finally, ε_{it} is the unexplained component in the brand level expenditure function.

In order to explore whether segments in vertical attributes are present and brand competition is more localised in the relevant segments of the market we use the approach in Hausman, Leonard and Zona (1994) to test for the presence of weak separability of consumer preferences across our segments. Equation 3 can be estimated with less segmentation reflected in the construction of real expenditure and average prices of other brands, and segment dummies. One constructs real expenditure on all brands in 20 flavour by packaging segments, 4 flavour segments, and in Carbonated Soft Drinks (zero segments). Likewise the weighted average of other brands prices could be averaged over less refined segmentation of the market.

Using Hausman specification tests we test whether the inclusion of real expenditure and the cross-price index defined for more refined

40 segments as additional regressors leads to efficiency gains in the estimation procedure. As additional regressors firstly compared to when real expenditure and the cross-price index is defined at the product level assuming no segments, secondly when segment expenditure and segment cross-price effects reflect 4 flavour segments, and finally reflect 20 flavour by packaging segments. This is how we intend to proceed to endogenously define the relevant vertical segments for clusters of brands within Carbonated Soft Drinks.

The IV Model

In addition to the problem of identifying segments of the markets for differentiated products, there is the problem of multicollinearity of prices and the fact that segment real expenditure may be an outcome of multi-stage budgeting, leading to the need of a good instrument for each of them. The multicollinearity of prices is addressed by exploiting the panel structure of the underlying data. Allowing for firm and segment fixed effects, we instrument the price of a firms brand in a segment using the prices of a firm' brands in other segments applying the econometric methodology of Hausman and Taylor (1981). The prices of a firms' brands in other segments, after the elimination of segment and firm effects, are driven by common underlying costs correlated with brand price but are uncorrelated with the disturbances in the brand demand equations. Availability of panel data is crucial. We instrument real segment expenditure with aggregate (net of segment expenditure) real

expenditure following Hausman, Leonard and Zona (1994). The need to instrument own-price and segment expenditure is tested using Hausman (1978) specification tests for instruments.

Results

The results of an OLS brand expenditure share regression within 40 segments are provided in the first column of Table 3. Due to some brand entry over-time the number of observations is 3159. Across segments, brand expenditure shares are significantly negatively related to real segment expenditures, or the size of the segment. Greater coverage of stores (weighted by size) in the first month t_0 enhances brand shares over bi-monthly periods. We observe that the estimated deflated own-price and the average deflated cross price of brands within the segment (weighted by store coverage) have, on average, a very significant negative and positive impact, respectively. The diagnostics on the residuals confirms that we find first-order autoregressive residuals and heteroscedasticity in the residuals, reflecting omitted variables among other factors.

Exploiting our panel on brands we allow for a brand random effect in residuals. The results of a GLS brand expenditure share regression within 40 segments, is provided in the second column of table 3. The results are largely similar in terms of observable explanatory variables but the effect of introducing unobservable brand specific effects reduces the first-order autoregressive process and heteroscedasticity in the residuals.

In column II we also report Hausman specification tests to see whether we get efficiency gains from the localised definitions of real expenditure and average prices, when compared to more aggregate measures of real expenditure and average prices of other brands across segments. The reported Hausman test, in all three cases, accepts the null hypothesis that the difference in co-efficients between the two specifications is systematic. To conclude, as in Hausman, Leonard and Zona (1994), we seem to have weak separability of preferences across our 40 attributes since we gain efficiency in our model of brand expenditure shares when we use real expenditures and price of the other brands defined for more refined segmentation of the market. The presence of an auto-correlated error structure of order one in the GLS models led us to adopt a transformation of the data to obtain the unbiased estimates of the coefficients presented for the AR(1) in column III which are largely the same as in column II.

The results of a GLS brand expenditure share regression within 40 segments, instrumenting real segment expenditure with market expenditure (net of segment expenditure) and brand own price with the average price of brands belonging to the same firm in other segments, are provided in column IV and, allowing for the presence of an auto-correlated error structure of order one, in the IVGLS, column V of Table 3. The results are largely similar, and the Hausman IV specification test accepts the null hypothesis that the difference in co-efficients between the two specifications is not systematic. It is possible that retail prices and segment expenditure

can be quite exogenous with respect to current sales movements, due to weather or seasonal effects and to the nature of retail pricing (see Hausman, Leonard and Zona, 1994).

Overall the short-run strategic interactions between brands are localised within vertical segments where competition is relaxed further within segments by various degrees of horizontal product differentiation.

Firm 'Role' Size Distributions Within Segments of Carbonated Soft Drinks

Our simple approach to modelling firm size distribution illustrates a structural feature that induces great stability in firm size distribution over the period examined, despite a high level of brand sale turbulence at a more micro level. The size of roles, or firm size within segments, depends on the intensity of competition between brands within segments. There are no theoretical restrictions on the shape of role size distribution within segments. Hence, the distribution of firms within segments can be either very skewed or very equal. This outcome is illustrated in Figure 5 for the 40 segments. This depicts the percentage of segment sales accounted for by the top k firms operating within that segment, ranked in ascending order of firm size within the segment. We observe a scatter of points that lie very close to the diagonal, and other more skewed distributions within segments. The scatter of points jumps around from one bi-monthly period to another. The Gini co-efficient

within each segment, averaged over the period, varies from almost perfect equality to 0.68. Competition between brands within segments, relaxed to various degrees by horizontal product differentiation, generate size distributions of firm sales within segments of various forms that change over-time. Compared to the overall firm size distribution, within vertical segments size distributions are more equal and in most cases violate the Sutton Bound. Yet, equality within segments does not induce aggregate equality at the level of Carbonated Drinks. Segmentation and heterogeneous participation of firms across vertical segments dictates a lower bound to firm size distribution in a market that is associated with a Gini co-efficient of 0.5.

Short-run strategic interactions between brands are localised within vertical segments. Differences in store coverage, among other factors, results in firm sales (roles) within segments of different sizes. Further product differentiation within segments pushes the size distribution inside a bound based on a pure count of product attributes. Turbulence in brand market shares within these structural dimensions of the market can be great but does not disturb the regularity in the firm size distribution in Carbonated Soft Drinks. Remarkably, product differentiation, and not short-run brand competition, resulting from firms acquiring various portfolios of stores and product attributes in market evolution determines the limiting firm size distribution. Coca-Cola Company is ranked one in the Carbonated Soft Drinks retail market in Ireland over the period 1992-1997, but its dominance does not result from its performance

within vertical segments. Rather its success lies in the establishment of a portfolio of brands across most of the vertical segments, distributed effectively throughout retail stores. Small firms can co-exist with the multinationals by specialising into product segments with targeted distribution.

Conclusion

The presence of flavour, packaging and diet segments within Carbonated Soft Drinks provides an ideal setting to empirically examine the role of portfolio effects as a very simple way to model firm size distribution in Carbonated Soft Drinks. Heterogeneity in firm coverage of product attributes imposes Sutton's (1998) mathematically predicted lower bound on the firm size distribution. Allowing for further firm heterogeneity in store coverage within segments induces a firm size distribution that is inside the bound and very close to the actual firm size distribution in Carbonated Soft Drinks. In the history of the market firms accumulate various portfolios of product attributes and stores, dimensions of the Carbonated Soft Drinks market that determine the limiting firm size distribution.

Taking a bottom-up approach we show that short-run strategic interactions between brands are localised within vertical segments and competition is relaxed further within segments by various degrees of imperfect shop coverage. We show that while individual segments host many forms of firm sales distributions, as an outcome

of brand competition within segments, this does not lead to a violation Sutton's lower bound or determine to a great extent the firm size distribution observed for Carbonated Soft Drinks.

This has the short-run implication that mergers of firms with brands that cover different product segments would have a much greater impact on market share distributions than mergers between firms with brands in the same segments. Success in the Carbonated Soft Drinks is based on the establishment of an effective (good distribution across stores) portfolio of brands across most of the product attributes. Small firms co-exist by specialising into these dimensions. The issue for anti-trust is whether portfolios effects are an outcome of anti-competitive forces.

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Table 1: Firm Roles and Brands in Segments of Carbonated Drinks Market, Oct.92-May 97

Segments	Mean Size (£000)	Mean % Share of Total Carbonated Drinks	Total No. Firms over period	Total No. Brands over period
Cans				
Regular Cola	2040	8.7	4	7
Diet Cola	519	2.3	3	5
Regular Orange	848	3.7	4	6
Diet Orange	100	0.5	1	3
Regular Lemonade	665	3.0	2	4
Diet Lemonade	256	1.1	1	2
Regular Mixed Fruit	988	4.3	6	8
Diet Mixed Fruit	17	0.1	1	2
Standard				
Regular Cola	1633	6.3	6	11
Diet Cola	417	1.6	2	3
Regular Orange	911	3.5	5	13
Diet Orange	19	0.1	1	1
Regular Lemonade	556	2.2	3	7
Diet Lemonade	96	0.3	1	1
Regular Mixed Fruit	3137	11.6	7	21
Diet Mixed Fruit	19	0.1	1	1
1.5 Ltr.				
Regular Cola	640	2.8	3	3
Diet Cola	212	0.9	2	4
Regular Orange	510	2.2	4	6
Diet Orange	51	0.2	1	1
Regular Lemonade	892	4.0	2	4
Diet Lemonade	394	1.8	1	2
Regular Mixed Fruit	447	1.9	6	7
Diet Mixed Fruit	1	0.02	1	1
2 Ltr.				
Regular Cola	1883	7.6	4	5
Diet Cola	518	2.1	3	5
Regular Orange	1320	5.6	4	5
Diet Orange	136	0.6	2	3
Regular Lemonade	1851	8.1	2	4
Diet Lemonade	671	2.8	1	2
Regular Mixed Fruit	2539	10.3	5	9
Diet Mixed Fruit	21	0.1	1	1
Multipack Cans				
Regular Cola	630	2.5	2	6
Diet Cola	206	0.8	2	5
Regular Orange	165	0.7	3	5
Regular Lemonade	117	0.5	1	2
Diet Lemonade	67	0.3	1	2
Regular Mixed Fruit	6	0.05	1	1
	24305	100	100	178

Table 2: Modelling Firm Size in Carbonated Drinks with 40 (Flavour by Packaging by Diet) Segments

(i) All variables are in logs; (ii) * significant at the 5 per cent level; (iii) t-statistics in parentheses;
(iv) GLS (a) refers to a random effects model and GLS (b) refers to a random effects model corrected for AR1
(v) Market Cycle and Relevant Market Cycle are net of the firm's sales.

(a) Segment coverage based on a count of segments that a firm covers

Firm Size	OLS	OLS I	GLS I (a)	GLS I (b)	OLS II	GLS II (a)	GLS II (b)
Segment Coverage _{t0}	1.67 (16.9) *	1.5 (11.3) *	2.14 (4.7) *	2.09 (5.2) *	0.86 (6.5) *	0.05 (2.2) *	0.12 (2.8) *
Market Cycle		-1.21 (0.9)	1.43 (3.8) *	0.92 (3.1) *			
Relevant Market Cycle					1.20 (18.2) *	1.31 (17.2) *	1.22 (10.9) *
Constant	2.09 (7.8) *	5.2 (2.2) *	-14.3 (3.4) *	-8.9 (2.7) *	-6.3 (5.9) *	-8.1 (6.2) *	-7.5 (6.2) *
No. Obs.	268	268	268	268	268	268	268
R ² Overall	0.52	0.53	0.50	0.51	0.62	0.62	0.62
R ² Within			0.06	0.06		0.54	0.54
R ² Between			0.57	0.58		0.63	0.63
Hausman Test: Random Effects			$\chi^2(1) = 0$			$\chi^2(1) = 0.03$	
Hausman Test for Less Segmentation: 20 flavourXpackage						$\chi^2(2) = 133$ prob> $\chi^2 = 0$	
Hausman Test for Less Segmentation: 4 flavour						$\chi^2(2) = 1135$ prob> $\chi^2 = 0$	
AR1	$\chi^2(1) = 221$	$\chi^2(1) = 216$	$\chi^2(1) = 119$		$\chi^2(1) = 221$	$\chi^2(1) = 43$	
Hetroskedasticity	$\chi^2(1) = 99$	$\chi^2(2) = 99$	$\chi^2(2) = 10$	$\chi^2(2) = 10$	$\chi^2(2) = 144$	$\chi^2(2) = 10$	$\chi^2(2) = 10$

(b) Segment coverage based on a count of segments that a firm covers, weighted by firms percentage coverage of stores in a segment

Firm Size	OLS	OLS I	GLS I (a)	GLS I (b)	OLS II	GLS II (a)	GLS II (b)
Weight Segment Coverage _{t0}	1.02 (26.5) *	1.00 (20.4) *	1.12 (7.6) *	1.09 (8.7) *	0.78 (15.9) *	0.68 (4.5) *	0.70 (5.6) *
Market Cycle		0.36 (0.8)	1.40 (3.7) *	0.89 (3.0) *			
Relevant Market Cycle					0.77 (7.4) *	1.29 (17.0) *	1.19 (10.8) *
Constant	5.72 (61.1) *	-9.45 (2.0) *	-8.9 (2.3) *	-3.7 (1.2)	-0.8 (0.9)	-7.5 (7.2) *	-4.6 (4.7) *
No. Obs.	268	268	268	268	268	268	268
R ² Overall	0.73	0.73	0.71	0.72	0.77	0.76	0.76
R ² Within			0.06	0.06		0.54	0.54
R ² Between			0.81	0.81		0.80	0.81
Hausman Test: Random Effects			$\chi^2(1) = 3.6$			$\chi^2(1) = 2.7$	
Hausman Test for Less Segmentation: 20 flavourXpackage						$\chi^2(2) = 114$ prob> $\chi^2 = 0$	
Hausman Test for Less Segmentation: 4 flavour						$\chi^2(2) = 8.7$ prob> $\chi^2 = .01$	
AR1	$\chi^2(1) = 198$	$\chi^2(1) = 196$	$\chi^2(1) = 119$		$\chi^2(1) = 198$	$\chi^2(1) = 43$	
Hetroskedasticity	$\chi^2(2) = 51$	$\chi^2(2) = 51$	$\chi^2(2) = 5$	$\chi^2(2) = 8$	$\chi^2(2) = 56$	$\chi^2(2) = 16$	$\chi^2(2) = 16$

(c) Segment coverage based on a count of vertical segments that a firm covers, weighted by firms effective coverage of stores (i.e. store share of carbonated soft drink sales) in a segment

Firm Size	OLS	OLS I	GLS I (a)	GLS I (b)	OLS II	GLS II (a)	GLS II (b)
Weight Segment Coverage _{t0}	1.16 (27.5) *	1.16 (21.3) *	1.29 (8.4) *	1.25 (9.6) *	0.88 (18.1) *	0.82 (5.1) *	0.88 (5.8) *
Market Cycle		0.004 (0.01)	1.42 (3.8) *	0.9 (3.1) *			
Relevant Market Cycle					0.83 (8.9) *	1.29 (17.1) *	1.18 (10.9) *
Constant	4.83 (48.0) *	-4.74 (1.0)	-10.1 (2.6) *	-4.75 (1.6)	-2.02 (2.6) *	-6.05 (8.4) *	-5.23 (5.5) *
No. Obs.	268	268	268	268	268	268	268
R ² Overall	0.75	0.74	0.73	0.74	0.80	0.79	0.80
R ² Within			0.06	0.06		0.54	0.54
R ² Between			0.84	0.85		0.85	0.86
Hausman Test: Random Effects			$\chi^2(1)=3.0$			$\chi^2(1)=2.1$	
Hausman Test for Less Segmentation: 20 flavourXpackage						$\chi^2(2)=6$ prob> $\chi^2=0.1$	
Hausman Test for Less Segmentation: 4 flavour						$\chi^2(2)=3546$ prob> $\chi^2=0$	
AR1	$\chi^2(1)=196$	$\chi^2(1)=198$	$\chi^2(1)=109$		$\chi^2(1)=196$	$\chi^2(1)=38$	
Hetroskedasticity	$\chi^2(1)= 45$	$\chi^2(2)= 48$	$\chi^2(2)= 5$	$\chi^2(2)= 5$	$\chi^2(2)= 45$	$\chi^2(2)= 18$	$\chi^2(2)= 16$

Table 3: Modelling Brand Competition in Carbonated Drinks with 40 (Flavour by Packaging by Diet) Segments

(i) All variables are in logs; (ii) * significant at the 5 per cent level; (iii) t-statistics in parentheses; (iv) GLS (a) refers to a random effects model and GLS (b) refers to a random effects model, with own price instrumented using a size weighted average price of a firms' brands in other segments, and segment size instrumented using real expenditure on all other segments. (v) initial weighted store coverage is the percentage of total carbonated sales that the stores covered by a brand account for; (vi) own price is paasch brand price; (vii) cross-price is a weighted (by store specialisation) average price of all other brands within a segment

Brand Expenditure Share	OLS	GLS (a)	GLS (b) Instrument Own-Price & Segment Size	GLS (b) Instrument & Correct for AR1
Segment Size	-0.39 (4.1) *	-0.43 (8.6) *	-0.82 (3.8) *	-0.35 (3.3) *
Weighted Store Coverage t_0	0.96 (37.0) *	0.94 (12.9) *	0.90 (3.2) *	0.95 (12.5) *
Brand Own Price	-0.53 (2.3) *	-0.57 (3.8) *	-9.8 (3.6) *	-1.4 (2.0) *
Cross-Price in Segment	0.28 (13.1) *	0.06 (4.8) *	0.08 (4.2) *	0.03 (3.3) *
Constant	-4.9 (6.1) *	-4.2 (3.0) *	1.9 (0.5)	-2.2 (1.8)
No. Obs.	3159	3159	3111	3111
R ² Overall	0.54	0.51	0.33	0.48
R ² Within		0.21	0.06	0.20
R ² Between		0.69	0.59	0.66
Hausman Test: Random Effects		$\chi^2(27) = 0$ prob> $\chi^2 = 1$		
Hausman Specification Test for less segmentation: Flavour by Packaging Only		$\chi^2(71) = 26$ 4prob> $\chi^2 = 0$		
Hausman Specification Test for less segmentation: Flavour Only		$\chi^2(71) = 42$ 9prob> $\chi^2 = 0$		
Hausman Specification Test for less segmentation: No Segments		$\chi^2(71) = 38$ 9prob> $\chi^2 = 0$		
Hausman Test: Instrumenting			$\chi^2(68) = 20$ prob> $\chi^2 = 1.0$	
AR1	$\chi^2(1) = 262$	$\chi^2(1) = 99$	$\chi^2(1) = 95$	
Hetroskedasticity	$\chi^2(71) = 210$	$\chi^2(71) = 64$	$\chi^2(68) = 69$	
Firm, Segment, and Month Dummies	Yes	Yes	Yes	Yes

Figure 1: Actual Firm Size Distribution in the Irish Carbonated Soft Drinks

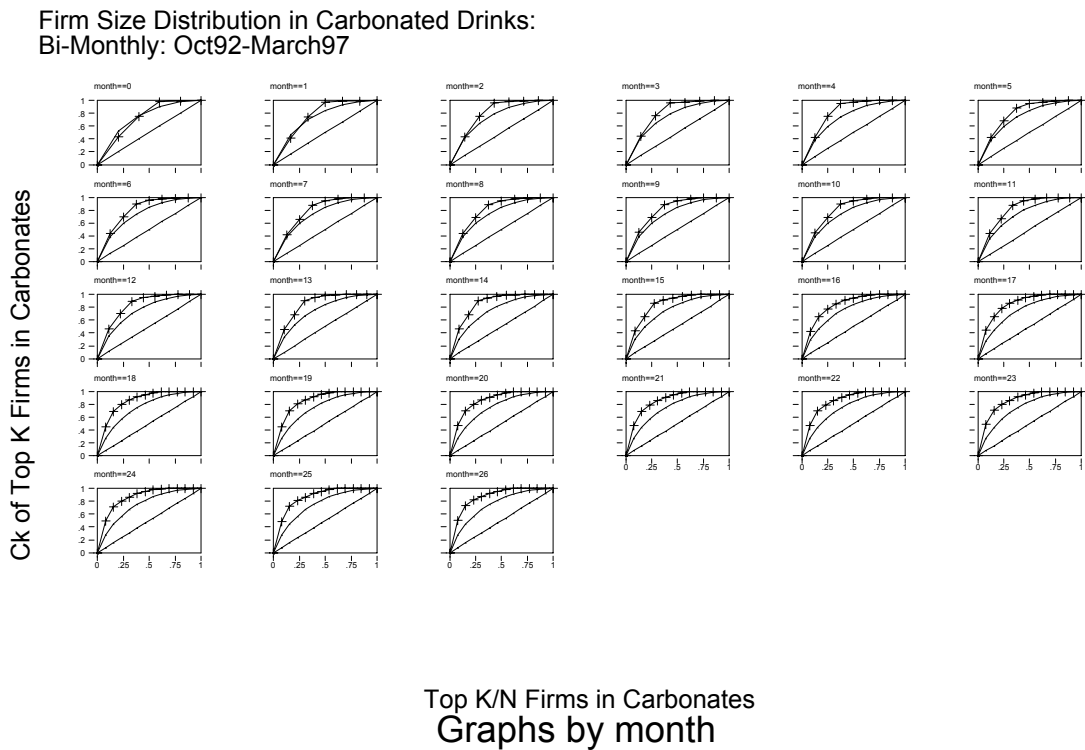
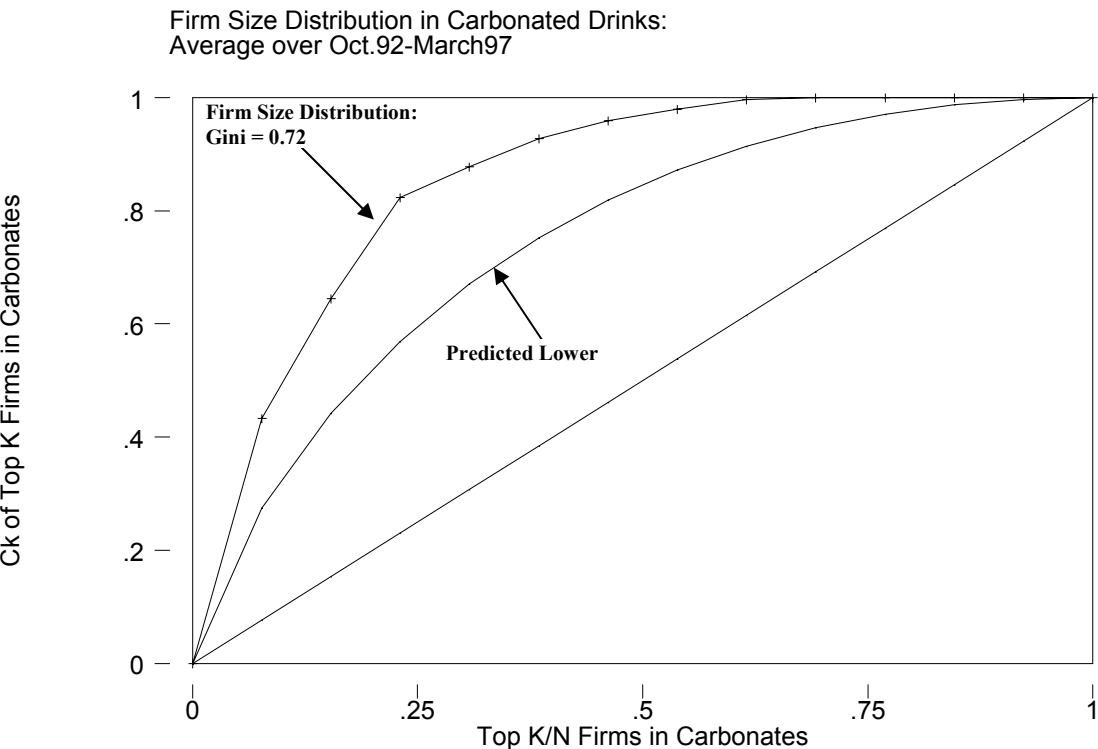


Figure 2: Firm Size Distribution Based on a Count of Roles over 40 Segments
(Flavour by Packaging by Diet)

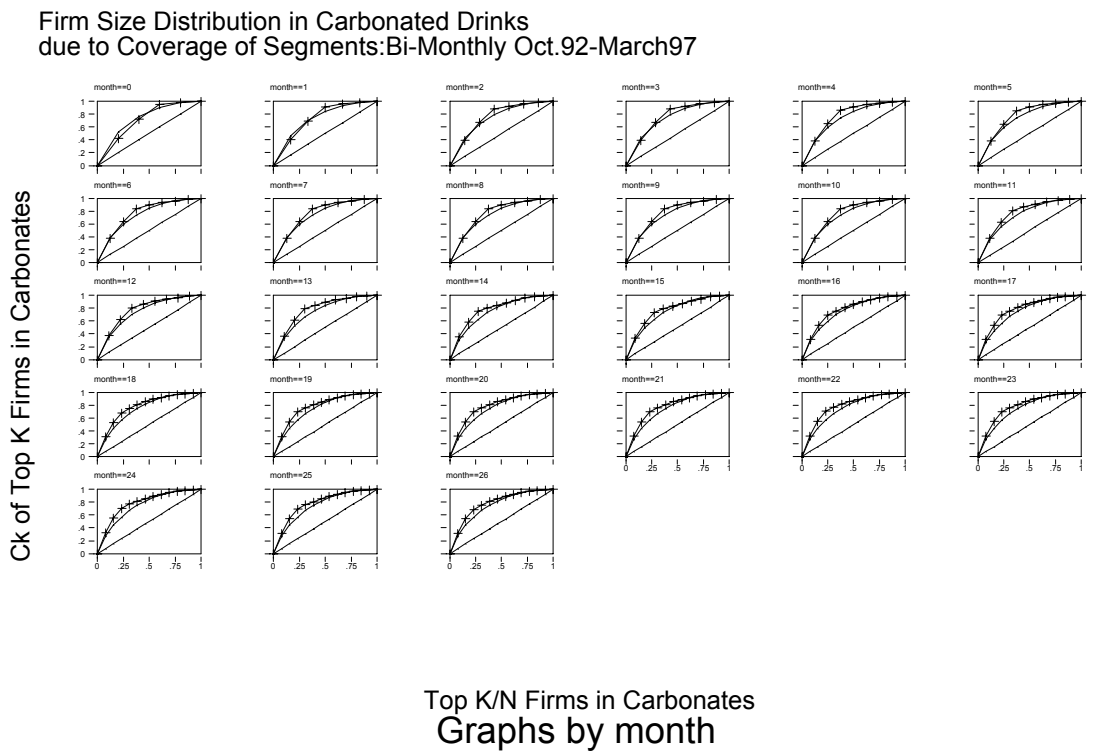
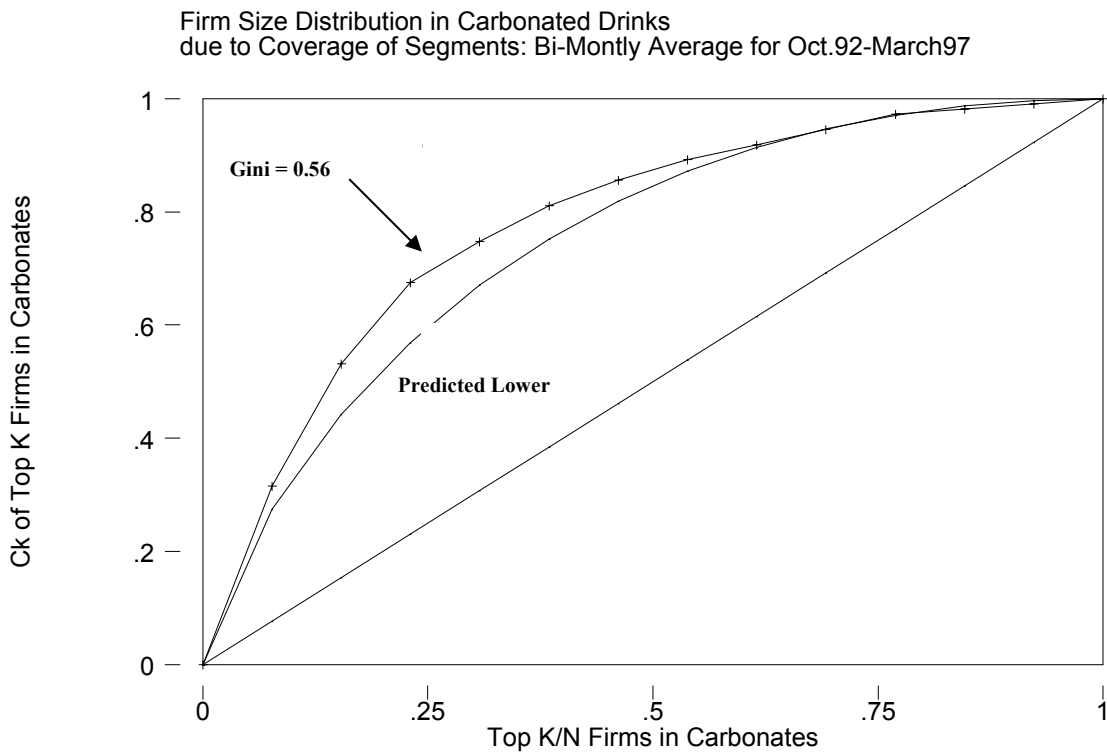


Figure 3: Firm Size Distribution Based on a Count of Roles, Weighted by Firm Coverage of Stores within a Segment, over 40 Segments (Flavour by Packaging by Diet)

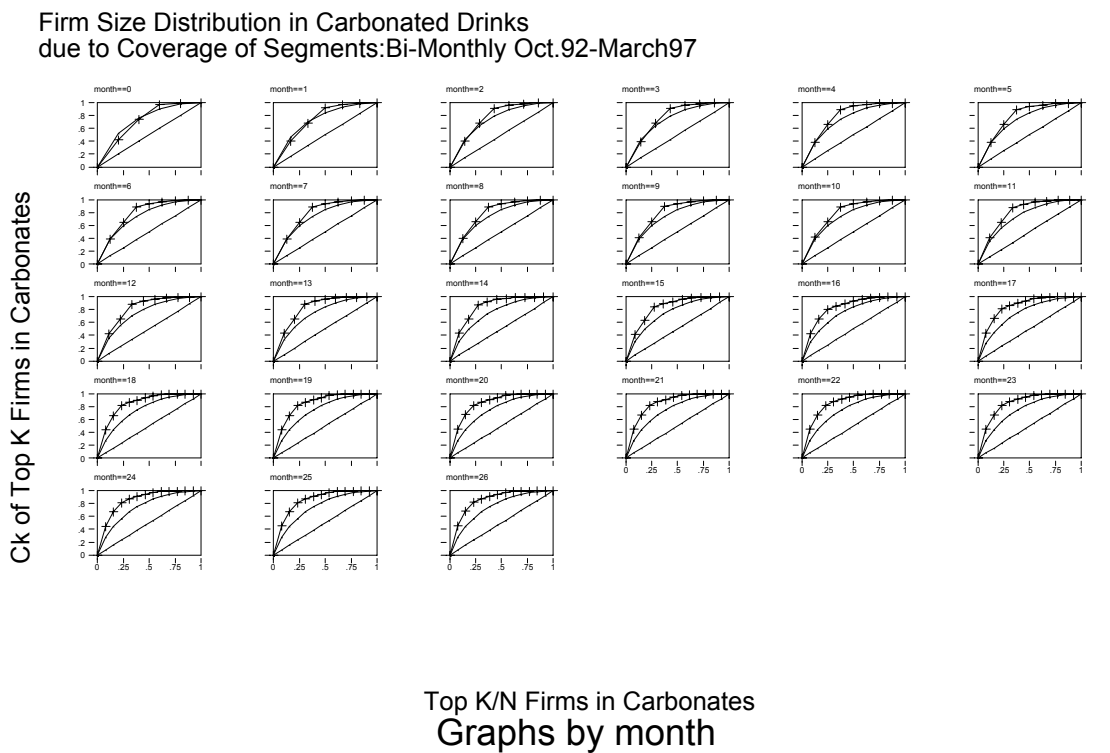
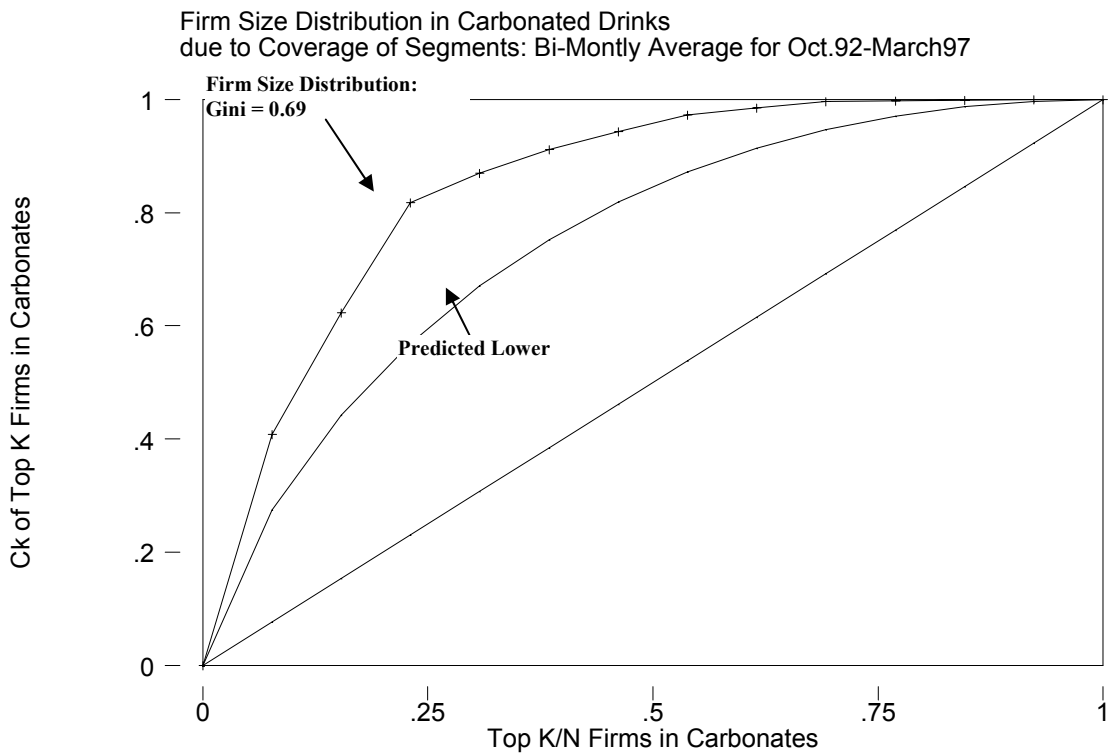


Figure 4: Firm Size Distribution Based on a Count of Roles, Weighted by Firm Effective Coverage of Stores within a Segment, over 40 Segments (Flavour by Packaging by Diet)

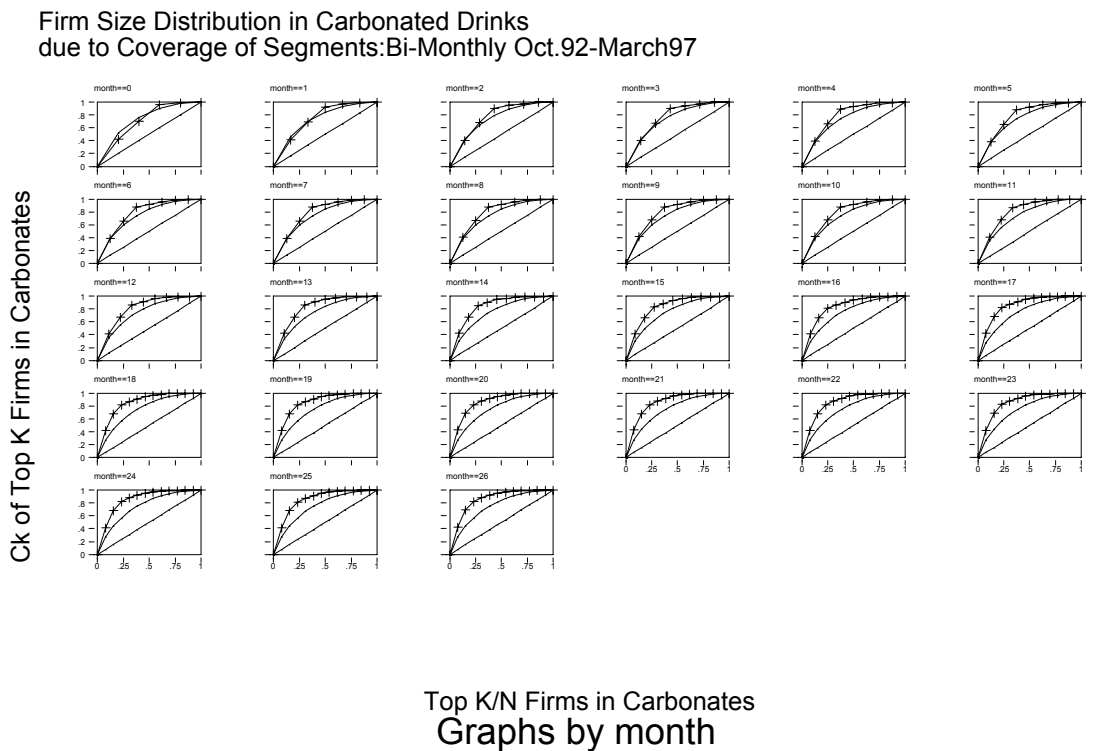
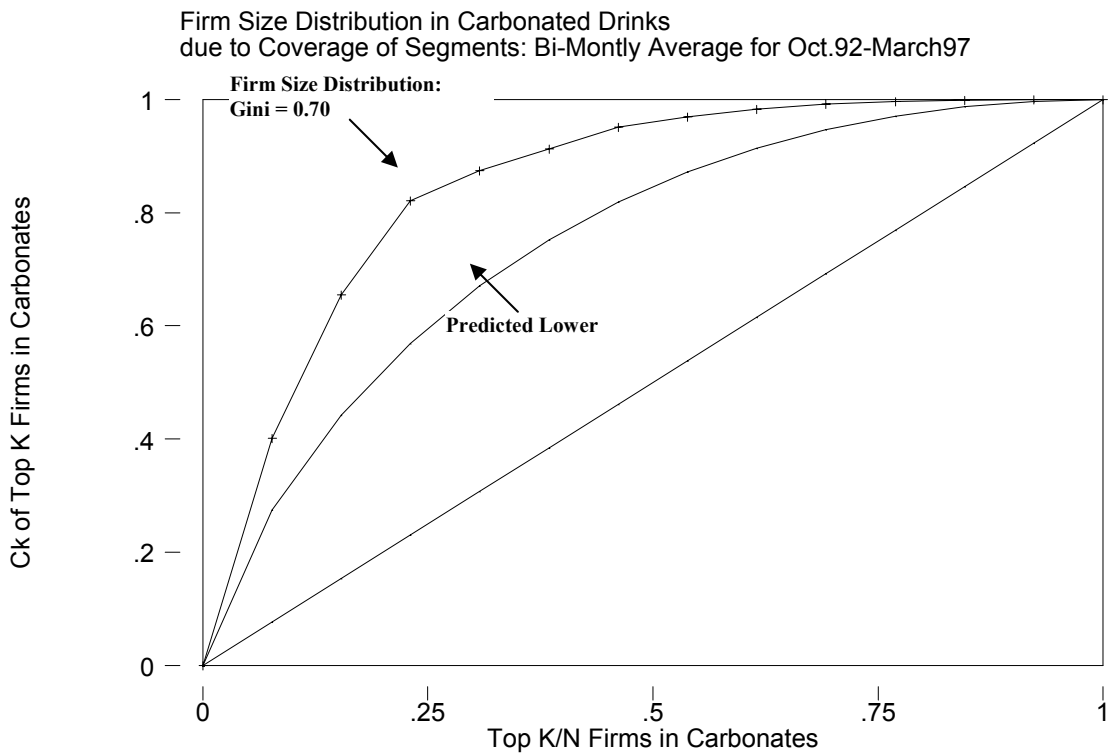
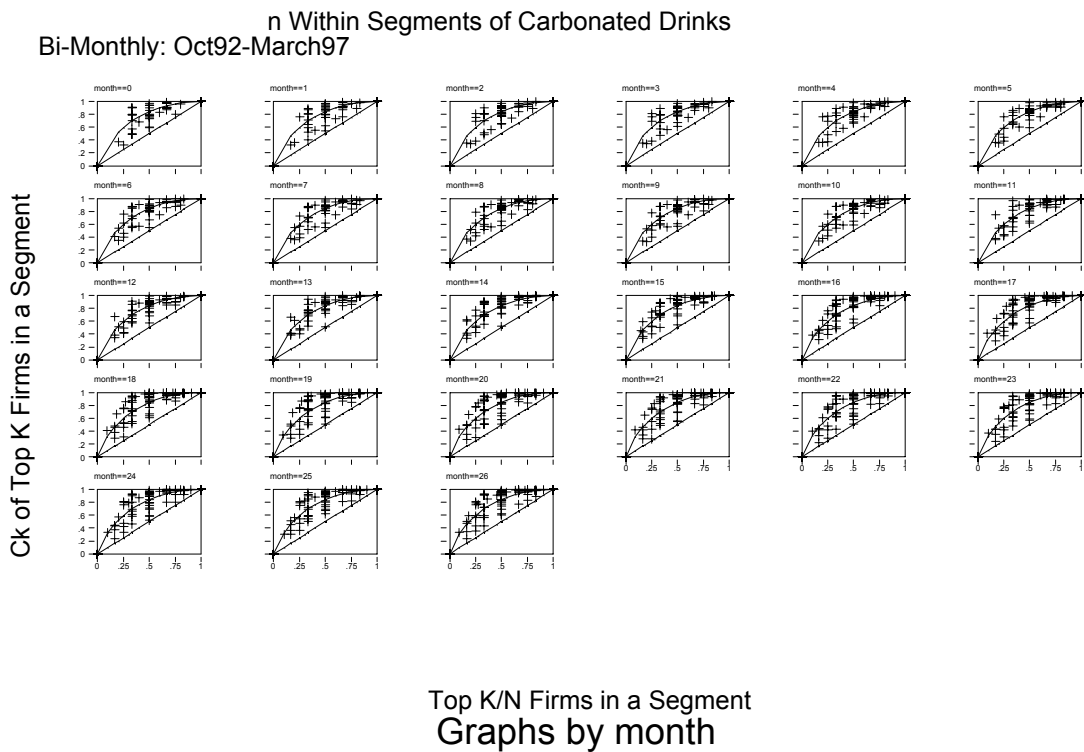
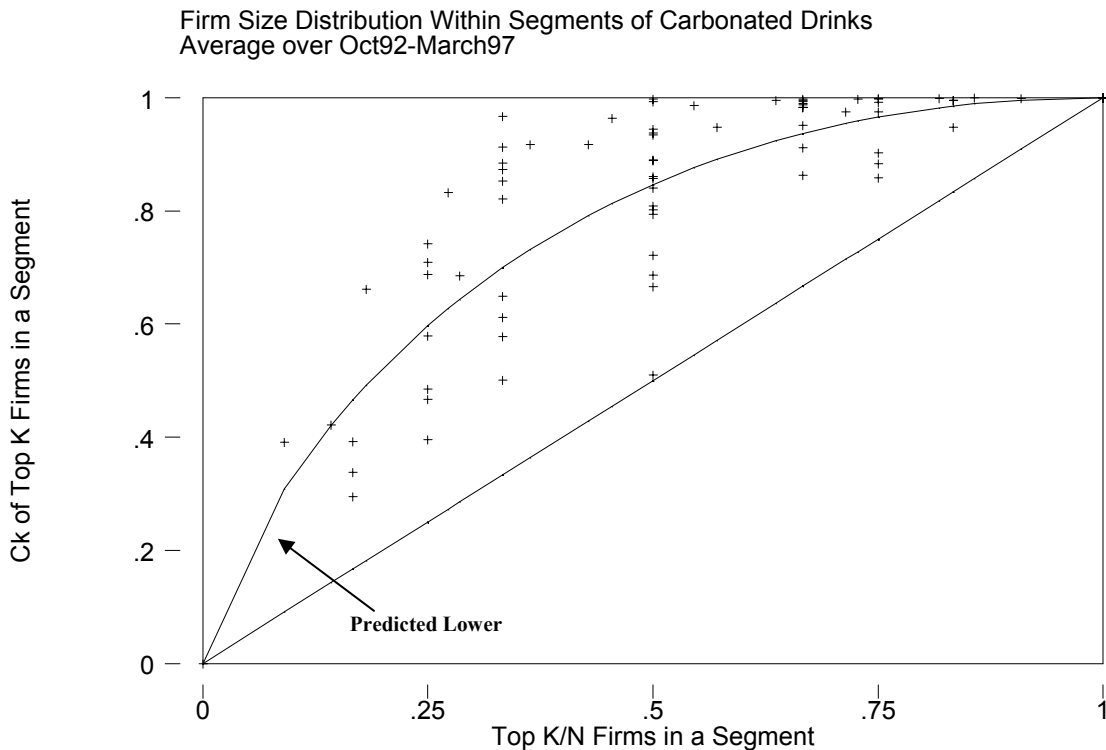


Figure 5: Actual Firm Size Distributions Within 40 (Flavour by Packaging by Diet) Segments in Carbonated Soft Drinkss



i. For a comprehensive review of this literature on firm size distributions, the reader is referred to Sutton [1997]. Gibrat [1931], using the mathematics of “stochastic processes”, postulates that the size-growth relationship for active firms generates size distributions approximately lognormal in form. Hart and Prais (1956) and Iijri and Simon (1964,1977) build in a stochastic entry process around Gibrat's size growth relationship for active firms. Unfortunately, simple generalisations on the form of firm size distributions, as outcomes of a historical stochastic processes, do not describe firm size distributions observed across the general run of industries.

Another strand of literature beginning with Dunne, Roberts and Samuelson (1988), using rich firm level data, suggest that the relationship between firm growth and firm characteristics, including size and age, is much more complex. Indeed theorists, such as Jovanovic (1982), tried to give the size-growth relationship an economic foundation and found the relationship to be sensitive to the details of modelling. In general, the vast volume of empirical studies testing growth, size and age relationships seem to agree that Gibrat's law fails and points to the success of idiosyncratic firm and sector characteristics. It seems that no general predictions can be made from short run dynamics on the form of limiting size distributions. This paper clearly demonstrates the nature of the relationship between short run dynamics and long-run size distributions in the retail market of Carbonated Soft Drinks.

ii Sutton (1998) marries the approach taken in Iijri and Simon (1964,1977) with the game theoretic approach used in Sutton (1991). In Sutton (1991), in the Bain [1951] tradition, stage games motivated differences in the lower bound to firm concentration that can be expected to exist across advertising and non-advertising branches of 4-5 digit food and drink products. In Sutton (1998) motivates a lower bound to firm size distribution that is modelled as an outcome of a sequence of deterministic entry stage-games across segments/investment opportunities during market evolution. Deterministic entry games replace the stochastic entry processes of Iijri and Simon (1964,1977).

iii Sutton (1998) in Part I of the book shows how the nature of tastes and technology within an industry puts a joint restriction on endogenous sunk cost outlays and the size and numbers of

segments that evolve in the history of the industry. In the context of Carbonated Soft Drinks if consumers were fully mobile across segments and advertising was very effective the market would evolve to be dominated by one segment. Tastes structures and advertising outlays, amongst other factors, have driven the degree of segmentation by product attribute documented in Table 1.

iv Transportation costs ensure that a firm has to have a production location in a state to serve the local market.

v To have a presence in a segment, a company must have at least one brand in a defined flavour, packaging and diet segment.

vi Retail sales data are fundamentally different to company accounts data for these firms, and have a number of advantages for our analysis. With company accounts data it may be hard to disentangle produce for export from that for national consumption. Company accounts data may consist of both intermediate and final goods. Finally, company accounts data can encompass a range of products that are not even closely related on the demand side of the market.

vii The introduction of foreign competition into the chain store market, which induced structural upheaval in the market, did not take place until the end of 1998. Both international and national companies distributed their brands throughout a retail structure that was very stable through the period analysed in this paper.

viii The Symmetry Principle is based on the Harsanyi and Selten (1988) concept of symmetry and subgame consistency.

ix The importance of controlling for the coverage of a firm, in terms of their distribution through a subset of stores, and the effective coverage of a firm, in terms of the size of stores within the product sales, is illustrated in Walsh and Whelan (1999b). Specialisation of distribution through a subset of stores can relax competition within a product market.

x. Only under the special conditions of very weak competition and overlapping of niches can theory predict the shape that the size distribution within niches must take. In this special case game theoretic analysis predicts an extremely fragmented outcome so that the Lorenz Curve for each niche must lie close to the diagonal [for an illustration, see Sutton 1998, Chapter 12]

^{xi} The entry games that took place in the history of the industry clearly determined the equilibrium configuration of product attributes and stores that we observe each firm holding at this stage of industry maturity. We take this as an important structural feature that disciplines firm size and localised brand competition over the short time span that we study the industry. Clearly such structural features are endogenous to the nature of industry evolution. Sutton (1998) with case studies of industries and Klepper and Simons (2000) with long time series data document the factors that determined how industries have evolved to endpoint structures.

^{xii} The basic problem in estimating demand for differentiated products is the dimensionality problem. A linear demand system for n brands has n^2 price parameters to estimate. They apply the multi-stage budgeting structure to a three-stage demand system. The objective is to estimate all three levels of demand and combine the estimates to calculate the overall own and cross price elasticities for each brand. The discrete choice literature, in a random coefficient model, shows one how to calculate the cross-price elasticities between all pairs reducing the dimensionality space into a product space, see Berry, Levinsohn and Pakes (1995). Our objective in this paper is more modest. We just want a simple test of market segmentation using the final stage of multi-stage budgeting used by Hausman, Leonard and Zona (1994). The main focus of the paper is on the imperfect and varying effective coverage of vertical segments by firms as a key determination of the firm size distribution. The main objective of this section of the paper is to show that the nature of localised competition between the brands within segments is consistent with the main focus of the paper.